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Patentanmeldung Nr.	Patent application No.	Demande de brevet n°
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Im Auftrag

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Service provision system for communications networks

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SERVICE PROVISION SYSTEM FOR COMMUNICATIONS NETWORKS

The present invention relates to service provision in communications networks and finds particular application

5   where a communications user is mobile.

Communication networks are growing increasingly complex as the information technology (IT) industry produces new and varied services to be offered to customers. The rapid provision of these services is expected to be a key

10   feature in distinguishing different network operators. Competitive advantages can be gained by communications network operators through the services that they offer, and the efficiency with which they manage those services. The customers (users) do not want to be aware of network

15   complexity, such as the relationship between fixed and mobile networks. All they want is simple access to any service, and this applies whether they are connected to a fixed network or using mobile facilities.

Embodiments of the present invention provide a service

20   management system, which can be used in the provision of services to a mobile user by means of more than one network platform. In particular, embodiments of the present invention can be used to provide services by means of a combination of a fixed and a mobile communications network,

25   in spite of the differing constraints such as the more limited bandwidth available in mobile networks.

It has been recognised, in making the present invention, that the use of "Cooperating Intelligent Software Agent" technology in a heterogeneous agent architecture can

30   allow service management in a complex environment such as the above. The basis for this technology is described in general terms in the publication "Distributed Artificial Intelligence" by M Huhns, Volumes I and II, published by Pitman, Morgan and Kaufmann in 1987. Indeed, cooperating

35   intelligent agents can be used to provide quality and flexibility of control sufficient to meet the demands of

leading-edge services, in spite of problems presented by
multiple network platforms with conflicting constraints.

Embodiments of the present invention can be described
as having a distributed architecture based on specialised
5 intelligent software systems, that is agents, which cooperate
to provide a range of services, some of which may be novel,
across a network platform provided by integration of, for
instance, a mobile and a fixed network platform. Software
agents for use in embodiments of the present invention can be
10 designed to manage systems where there is a large amount of
distributed information available and a large number of users
with specific service requirements. Generally system
management becomes more complex where users move between
fixed and mobile networks while requiring/receiving services.
15 This raises the problem of unifying the provisioning of
services across various network platforms (mobile and fixed)
and the effective management of the limited radio spectrum in
contrast with the less constrained bandwidth in the fixed
(broadband) networks.

20 A major problem foreseen with communications systems
of the future is system complexity which is expected to limit
the ability to exploit and reliably control communication
networks. Intelligent agents used in embodiments of the
present invention can achieve simplicity and robustness by
25 spreading a control system over a plurality of specialised
agents.

One type of agent provides the customer with an
interface to manage the customer's interactions with the
network, another cooperates to manage the network resources
30 (cell bandwidth or capacity along the fixed network links)
and a third type of agent facilities specific services by
linking network and customers together. As a result of
agents interaction, intelligent services with special
features that satisfy the customer and make better use of
35 network resource, can be provided.

The agents accomplish their tasks by exploiting only
local knowledge and using limited communications to inform

each other of their actions and/or pass knowledge. They negotiate with each other and by deciding the best option allocate tasks within the system. Their distributed nature makes them tolerant to both individual and multiple agent

5   failure. This agent-based approach gives fast, robust and near-optimal solutions to resource allocation problems.

A service provision system according to an embodiment of the present invention will now be described, by way of example only, with reference to the accompanying Figures in

10 which:

Figure 1 shows an environment in which the service provision system would be advantageous;

Figure 2 shows a schematic diagram of a heterogeneous agent architecture for use in the service provision system

15 described below; and

Figure 3 shows schematically the relationship between network management software agents and a network over which they have control.

Referring to Figure 1, an environment in which the

20 service provision system might be applied comprises a fixed communications network 1, which may for instance be a broadband network, in combination with radio transmitters 2 of a mobile network.

The fixed (broadband) network 1 is the main carrier of

25 long distance traffic and is represented for the purposes of this example to consist solely of Digital Main Switching Units (DMSUs) 3 which are nearly fully interconnected. Houses 4, offices 5, other buildings etc are assumed to be connected in known manner to an appropriate node of the fixed

30 network 1.

The radio part of the network is arranged into large (~10 km diameter) macro cells 6 and smaller (~500m diameter) micro cells 7. The former provide country wide coverage but a low bandwidth, the latter service local 'hotspots' with

35 higher bandwidth available. Additional services are available through much higher bandwidth, small pico cells 8 - typically only a few meters across. These are assumed to be

located in offices 5 and at special location points such as garages, railways stations, motorway service stations, shopping centres etc. All radio cell transmitters 2 are connected in known manner to their local fixed network node.

The customer (user) may be mobile, travelling across cell boundaries 9 and requesting various services through his mobile handset, or may be at a fixed location having access to the integrated network through a terminal (ie video-telephone or computer terminal).

In this scenario, there will be at least one network provider involved, who provides and manage s either one or both of the fixed and mobile networks concerned. There will also be at least one customer, who has access to one or both of the networks and may require services such as telephone calls or data provision, and at least one service provider. The service provider(s) may be independent of the network provider and merely provide services which are accessible by means of the network(s).

Normally any requested service will involve an end-to-end connection across the integrated network platform to another mobile/fixed customer or to a bank of data located anywhere in the network. For instance, the data might comprise any kind of stored information (text file, image file, manual page) that the customer would like to access for information retrieval or storage.

Agents Architecture

Referring to Figure 2, the following describes a heterogeneous system architecture based on autonomous agents working cooperatively to solve various service management problems in the mobile and fixed integrated network (MFIN) 10, shown in Figure 1.

The agents form a single layered system using the underlying fixed network 1 for inter-agent communication.

The agents involved in the architecture can be grouped into three generic categories:

- Interface agents comprising Customer Agents (CA) 20 and Gateway Agents (GA) 21.

5 - Service Provider Agents (SPAs) 22

- Network Management agents comprising Fixed Network Agents (FNA) 23 and Cell Agents (CLA) 24

A Customer Agent ÇA 20 mediates between the agent
10 system 25 and the customer while a Gateway Agent GA 21 provides a link such as a port, or interface, between the agent system 25 and another intelligent or non-intelligent management system (not shown) owned by an independent telecom operator.   Hence, GAs 21 facilitate the transfer of
15 information or requests between the agent system 25 and the external world.

The Service Provision Agents 22 are each responsible for a specific service, managing information about the provider(s) of that service and negotiating with those
20 providers who wish to sell their resources.   In an example, a customer might require some specific data but that same data may be found at different locations.

In principle, each agent is allowed to communicate with any other agent in the community with the exception of
25 SPAs 22 which have communication channels only with Customer Agents (CAs).   This provides a security measure in that SPAs 22 for service providers who are independent of the relevant network provider(s) are prevented from having direct access to network management or customer information. SPAs 22 are
30 service-specific, and actual provision of a service to the system 25 is done by means of a CA 20.   Hence, in practice, a CA 20 provides a customer request to an SPA 22 which then decides which other CA 20 (responsible for the resource required) should be contacted in providing the resource.
35 Thereafter, the CAs 20 involved, the one providing the customer request and the one associated with the resource,

contact the network management agents which will set up the service.

The Network Management Agents are mainly responsible for managing resources in the fixed network (FNAs) 23 and in the mobile network (CLAs) 24. As shown in Figure 2 the Cell Agents 24 can be of various types, depending on the type of cell they are managing: Macro Cell Agent (CLA - M), Micro Cell Agent (CLA - m) or Pico Cell Agent (CLA - p). The Network Management Agents work cooperatively to collate their available local resources (i.e. link capacities and cell bandwidth) in a "resource configuration" required for a particular service. They also continuously update that resource configuration to deal with changes of delivery point for the service due to customer's mobility.

Agents communicate by passing messages of fixed format.

Messages have the generic form: [To, From, Job_ID, Content]

'To' identifies the agent or list of agents the message is sent to, 'From' identifies the originator agent sending the message, job id is a marker used in tracking jobs through the system, and 'Content' is the inter-agent message. When receiving a message each agent makes its own decisions triggering an internal task and/or deciding to communicate with other agents sending or requesting information.

The agents' internal structure and the main functions performed by each of them are described in the next section.

Agents

The generic types of agent presented and their identifiers are:

Network management agents:

Fixed Network Agent 23 (FNA)

Macro/micro/pico Cell Agents 24 (CLA-M, CLA-m, CLA-p)

Interface management agents:

Customer agents 20 (CA)

Gateway agents 21 (GA)

Service provision agents 22 (SPA)

5 <u>Network Management Agents 23, 24</u>

The role of network management agents is to manage, monitor and cost the provision of the basic network resources needed to provide a service. Each FNA 23 is responsible for managing a network node and each CLA 24 is responsible for
10 managing a cell transmitter 2. The mapping between various types of network management agents and the physical integrated network is given in Figure 3, where the M, m, p are identifiers for the Macro, micro and pico agents respectively.

15

i)   <u>Fixed Network Agent (FNA) 23</u>

These agents manage the flow of data through a network node and its associated links. (It should be noted that a node in this context is a switching unit, not shown, which is
20 smaller than a DMSU 3. Multiple nodes may be connected to a single DMSU 3, and a single FNA 23 can

manage more than one node).

<u>Knowledge (stored & updated)</u>

-       local network topology (links and node(s) managed)
25 -   neighbouring agents topology

-       active services along managed links

-       bandwidth usage

-       price-bandwidth table

<u>Functions Performed</u>
30 -   Monitor   bandwidth usage along their managed physical links

-       Cooperate with other FNAs using a distributed routing algorithm to find the shortest available route in the fixed network for a requested service
35 -   Dynamic update of the route found through the fixed network on customer departure from the area managed by the

FNA (that is, when a customer leaves the cells connected to the FNA and enters the area of another FNA)

- Cooperate with the CA 20 to find not only the mobile customer location (i.e. in which cell) but also if that is

5 the right cell in terms of bandwidth required for the service. This facility is used for intelligent downloading of data cached when the available cell bandwidth allows it.

- Set up the service end-to-end connection merging the fixed network path with the radio paths to a customer's

10 current cell

- Control data caching at its site and then download it along the end-to-end connected path

References are made above to "data caching". This

15 *covers* the storing of data which a customer requires for transmission to the customer when the customer reaches a location at which downloading is possible. For instance, a customer may request a service requiring significant bandwidth at his/her location, and subsequently move to a

20 location in which the bandwidth is no longer available, for instance by moving from a pico cell to a macro cell of a mobile network. The relevant data must therefore be cached until such time as the customer moves once more to a location where downloading is possible.

25

ii)   **Cell Agent (CLA) 24**

For each cell in the integrated physical network 10 there is a Cell Agent 24 controlling it. Macro cells are arranged so that each is connected to only one FNA 23.

30 Micros and picos are all encapsulated in macros and are connected to the macro cell in which they are embedded. Similarly, in the event that a pico is embedded geographically inside a micro it is connected to that micro cell. As shown in Figure 3, the cell agents 24 follow the

35 same connectivity pattern as the cell transmitters 3.

<u>Knowledge (stored & updated)</u>
- parent cell agent connected to
- active services using that cell's bandwidth resources

<u>Functions Performed</u>
- Monitor bandwidth usage inside the cell they manage
- Dynamic price allocation based on current bandwidth usage level
- Monitor customer entering/leaving the cell and signal their presence to his Customer Agent 20 via the parent cell agent, if any, or via a FNA 23 if connected straight to an FNA agent
- Continuously offer resources to the Customer Agent 20. The message sent includes the following tuple:

[Customer_Agent, Path, Bits, Price]

where:

Path is the paths from the FNA 23, down to that cell agent.

Bits represents the available bandwidth on offer

Price is the desired selling price worked out by the cell agent

The last function presented above is central to the system, creating the possibility for resource managers of the network providers to offer continuously available resources at variable price (depending on the current bandwidth usage) to potential customers and not only when those resources are required by a requested service. This increases the potential usage of network resources and implicitly creates new and flexible opportunities for the customer wanting to use those resources.

When a service is established (by negotiation with the resource managers) the service is implemented by the resource managers, on behalf of the network providers rather than the service providers. At this point, a data download makes use of caching facilities provided by the fixed network.

Thus, the network management agents' job is to sell resource at a price that they dynamically allocate based on current bandwidth usage.

5 **Interface Agents**

i)   **Customer Agent (CA) 20**

The role of the Customer Agent 20 is also very important in the system.   It provides a 'one interface per customer' facility for various types of customers.

10   A main role is to present and negotiate customer requests for services with the system.   Another major role however, is to offer proactively various services to the customer when and where they become available to him/her.

Additionally, a customer may not only request a 15 service but may also offer resources that other customers want to use(i.e. databases of information, people resources).   The functions of the Customer Agent can be expanded to take this into account.   The following provide examples of relevant customer agent types:

20   -   Personal Customer Agent (deals with a person offering services or capturing services requirements)

-    Database Customer Agent (manage data resources, sell data to other agents/customers)

-    Computer Customer Agents (manage processor resources, 25 provision of on/off line computation power)

For the purposes of the present description, further details of the design/function requirements of the first two types of Customer Agent 20 are given below.   (These are relevant to the descriptions of the system in use given under 30 "Scenarios and Services" below.)

Personal Customer Agent
Knowledge (stored & updated)
-    customer's current location
35   -   customer's business profile (history of services requested by the customer, although this may be a facility of

a future business agent which may be added to the current
system)

-        generic range of services offered by the relevant
operator

5 -   payment requirements pre-input by the customer
(optional)

-        billing and pricing information

Functions Performed

10 -   customisable interface (one customer agent is created
for each customer)

-        takes customer's request for service information and
mediates the dialogue with the service provider agents (SPA)
22 sending information back to the customer

15 -   receives resource offers at a certain price from the
network management agents 23, 24 and matches them against the
range of services deciding which services can be provided to
the customer

-        allocates prices to services based on the price of
20 network resources on offer and weights them in accordance to
customer's business profile

-        offers those services to the customer (i.e. sends
available service information (Service_Type, Price) to appear
as distinctive icons on the customer's mobile handset
25 display: the customer deciding to take advantage of the
service offer then has only to select the relevant icon)

-        after taking in the customer request for a service,
puts it forward to the service provider agent 22 (eg Road Map
Provision agent) and then sends a request to the relevant
30 network management agents 23, 24 for service set-up)

-        all incoming services are checked by a CA 20 before
contacting the customer (to take account of call blocking,
priority interruptions)

-        while a service is active and the customer is moving
35 the Customer Agent continuously sends messages updating
customer's current location to the network management agents 23, 24
for route (of the service) update

- Monitor service quality (if there is not enough bandwidth for that service in the current customer's cell, the CA 20 receiving the resource offer from the cell may decide to downgrade the service - *eg* video link to audio -

5 if this is agreed by the customer, or use the caching facility, in the case of data transfer to the customer, to put the service on hold till a new 'valid' bandwidth offer arrives from another cell the customer moves into)

- take customer request to cancel the service and inform

10 the other agents responsible for the service (i.e. the network management agents 23, 24 to release the bandwidth previously used in the service).

In the early stages these agents will check a request against internal criteria, price it by business directed

15 pricing and establish contacts with the resource management agents to build the service. Later generations will learn patterns of customer behaviour, price services to stimulate revenue inside the constraints set by business agents and negotiate the best rate for the necessary resources.

20

Database Customer Agent

The Database Customer Agent is the interface attached to any bank of data that the system may facilitate access to, for various other personal customers.

25

Knowledge (stored & updated)

- Database location and its connectivity to the physical network
- generic range of items offered by the database

30 - generic payment information
- current utilisation of database resources

Functions Performed

- allocate prices to database services based on the

35 current utilisation of data resources
- offer those priced services in response to the service provider agent's request

- after being chosen by the service provider agent 22 as a source of data, the Customer agent 20 sends a request to the relevant network management agent 23, 24 (closest FNA 23) for data caching .

5 - when it receives the network management agent (closest FNA 23) acknowledgement the Database Customer Agent validates the transfer of data to be cached at FNA 23 site.

ii) Gateway Agent (GA)

10 Gateway agents *translate* between systems, effectively providing a language translator enabling different systems to negotiate. If the other system is not intelligent and does not negotiate, the gateway agent can act as a shell providing an intelligent interface. Note this suggests one gateway 15 agent per network interface.

Service Provision Agents 22

Service provision agents 22 are not a generic family. Each type of service that can be offered is operated by a 20 service provision agent. Their job is to provide the link between *services* and network. For simple point-to-point services such an agent is relatively simple. However by breaking service provision down in this way we can provide intelligence where it is needed. A service provision agent 25 22 can buy and sell (negotiate for) data, computing resources, people or network bandwidth from the customer agents interfacing with such resources or from network management agents.

This enables the provision in a simple fashion of new 30 intelligent services. Rather than describe all the possible details of such agents, a typical example is given below as the SPA agent used below in the "Intelligent Services" scenario.

35 Knowledge (stored & updated)

- Engineers it is managing
- Customers registered with the service

- Generic payment information
- List of customers in need of service
- Know where data on cars is located

5 <u>Functions Performed</u>
- request time-distance to customer from engineers
- match engineers to customers
- inform engineers of next job
- buy car repair data to pass to engineers in need

10

This service provision agent provides the network operator effectively with two customers - the person who is requesting the service and the company (service provider) who runs the breakdown service. Service provision agents 22 can
15 act on behalf of more than one network customer.

<u>Scenarios and Services</u>
The following three scenarios have been chosen to demonstrate use of the service provision system described
20 above.

<u>Interactive Service Provision</u>
In this scenario a customer moves between different types of radio cell. The system will detect such cell
25 changes and uses the cell change to inform the customer's home register of his location. In this scenario a "hardware" signal is directed to the cell agent 24 and the phone effectively represents the customer. This cell agent 24 examines the current traffic load in the cell and uses an
30 algorithm to select a capacity and price for use of the cell's facilities. It then offers this capacity-price tuple to the customer agent 20 of that customer. The customer agent 20 then checks the range of services that the customer has subscribed to, including any price limits the customer has
35 requested, checks the price offered by the cell against any current business strategies for pricing calls and offers a list of service-price tuples to the customer's phone unit.

These are displayed as icons on a display the phone unit, with appropriate pricing included.

The services offered will vary from cell to cell, with available capacity. A point-to-point continuous service that
5 is extant on crossing a cell boundary but which requires more capacity than is then available, in the new cell, or which would require a significant increase in cost (say a video call on moving into a macro cell from a micro), will be either downgraded by the customer agent to a lower call type, or
10 will show an increased cost. Data services which do not require a continuous link are managed differently (see "Intelligent Data Services" below). The services displayed can include normal telephony, compressed video, full video, one-touch emergency services and two data download services,
15 for instance.

It is envisaged that this iconic interface gives rise to the following significant advantages:
*   The customer can see all the services available in a given cell at a single glance
20 *   Price information is available at the point of sale
*   Marketing can be done at the point of sale

This scenario shows the interworking of network and customer agents.

25

Intelligent Data Services

In this scenario the customer and network agents 20, 23, 24 combine to download data intelligently. A customer requests a data download to his computer, or road maps to
30 his video phone etc. It is assumed that his machine wants the data quickly and cost effectively. The parameters on either could be set by the customer. For instance, the customer might specify that he wants data to be downloaded at 64 Kbit/s. He may however be in a typical macro cell,
35 offering only a voice channel (8 Kbit/s). The data is then retrieved, and cached by a fixed network agent (FNA) 23, but not sent yet to the customer.

The network agent 24 requests that the customer agent
20 informs it as soon as the customer is in a cell with the
right price-capacity values. Once informed the network agent
23 downloads as much data as possible until the customer
5   agent 20 informs it that the customer is again changing
cells. The data connection thus tracks the user round the
system, exploiting the available capacity (or price) as
available.

10   **Intelligent Services**
A third scenario demonstrates intelligent service
agents. Their job is to coordinate customer agents 20 and
network resources as appeared in the previous scenario. In
this scenario they demonstrate value-added intelligence of
15   their own.
A customer is in a car which breaks down. He touches
the "emergency breakdown" icon on his screen. The call is
connected to a service provider agent (SPA) 22 which requests
location and fault description. The service provider agent
20   22 manages a group of engineers in the field. It
interrogates their customer agent 20 with whom each engineer
logs his current job status. The service provider agent 22
negotiates with the customer agent to find an engineer who
can most quickly be directed to the job then downloads the
25   information required to the engineer. The service provider
agent 22 thus acts on behalf of two customers - the broken
down customer and the engineer agency. Such network
intelligence could be used for any dispatch service which
involves scheduling. Currently it is implemented as a
30   reactive, negotiation based service but alternative
algorithms could be implemented.
The main features of this service are:
*   Provides a complete application for scheduling
engineers
35   *   One touch service to customer - no numbers to remember
*   Can be expanded to range of services with the
intelligence in the network

*   Each service has a dedicated service agent - easy to produce new services.

CLAIMS

1.   A service provision system for use with a communications

network to provide a plurality of services to a network user,

wherein data relevant to the plurality of services can be made

available to the user, and the user can select one or more

services to be provided, said system including control

means comprising a plurality of software

a its, individual agents of said plurality comprising

data in respect of respective entities relevant to service provision

by means of the network, said

system further comprising updating means for updating data held

by at least some of said software agents,

the control means controlling the data made available to the user and

responsive to selection of a service by the user to trigger a process

for providing the selected service to the user.

2.   A system according to Claim 1 wherein said communications

network comprises at least in part a mobile communications network and

the user has access to said mobile network.

3.   A system according to Claim 2 wherein the control means is

responsive to transfer of the user between cells of the mobile

network, said cells having different resources to offer in respect of

services to the user, to update data made available to the user which

is affected by said transfer.

4.   A system according to Claim 3 wherein at least one of the

services potentially available to the user is affected by bandwidth

availability in the cell in which the user has access to the mobile

network, and the control means may update the data available to the

user in terms of either availability of such service or the price

at which it would be available.

5.   A system according to either of Claims 3 or 4 wherein at

least one of the services potentially available to the user

involves the downloading of data to the user, which downloading

is affected by bandwidth availability in cells of the mobile

network, said system further comprising means to store data

requested by the user as a consequence of selecting a service,

the control means controlling downloading of said data to the

user such that it is stored at times that bandwidth is not

available for said downloading, and downloaded subsequently

ɩ ₋ɪɪ bandwidth becomes available.

6.   A system according to Claim 5 wherein the control means

includes means for tracking the location of the user with respect to

the mobile network for the purpose of downloading the data

to the user by means of appropriate routing through the communications

network or networks.

Fig.1 Integrated Fixed & Mobile Network - Physical Topology

DMSU

radio transmitter

Macro - Cell

Residential/Garage

Office

Mobile Customer
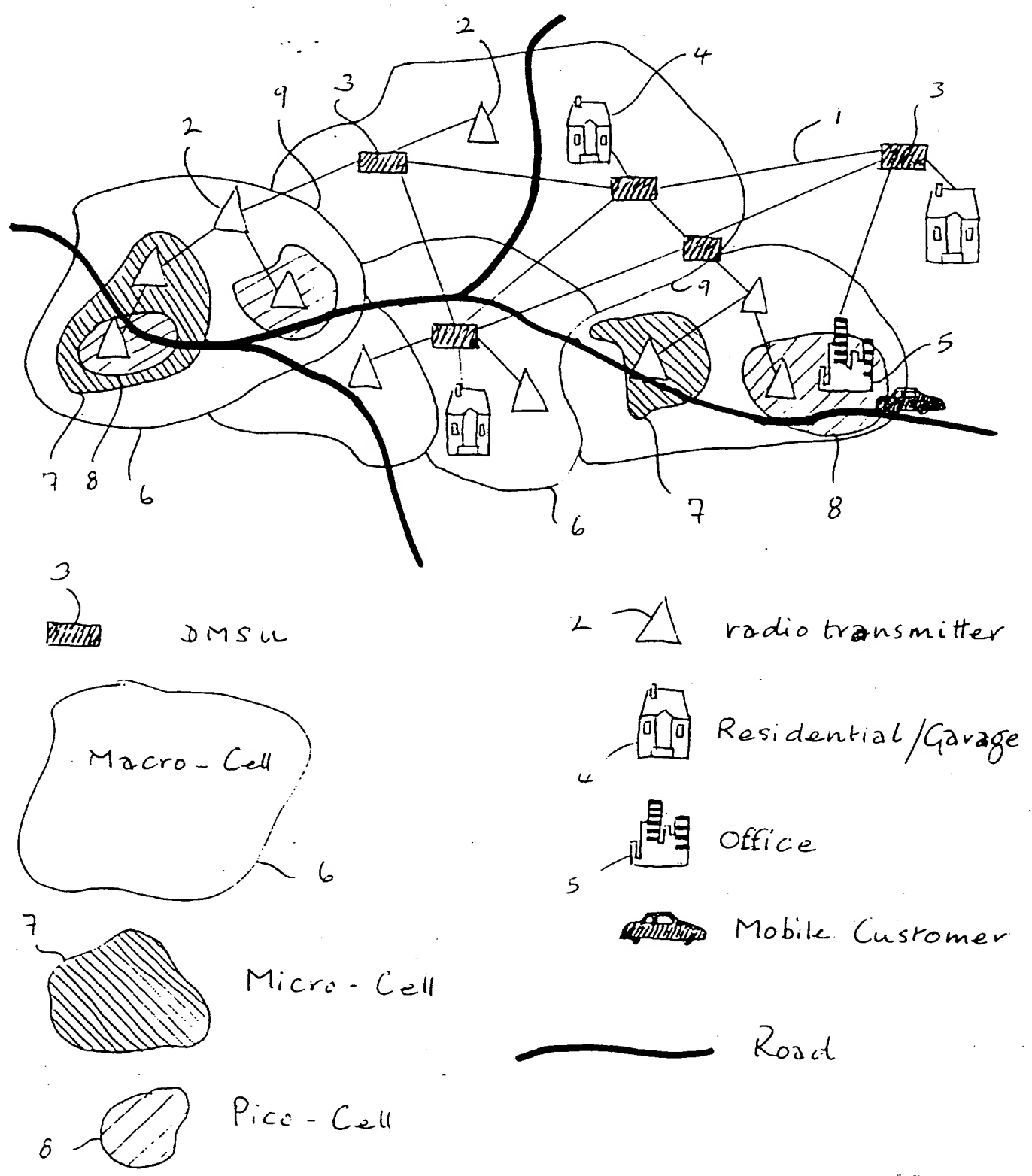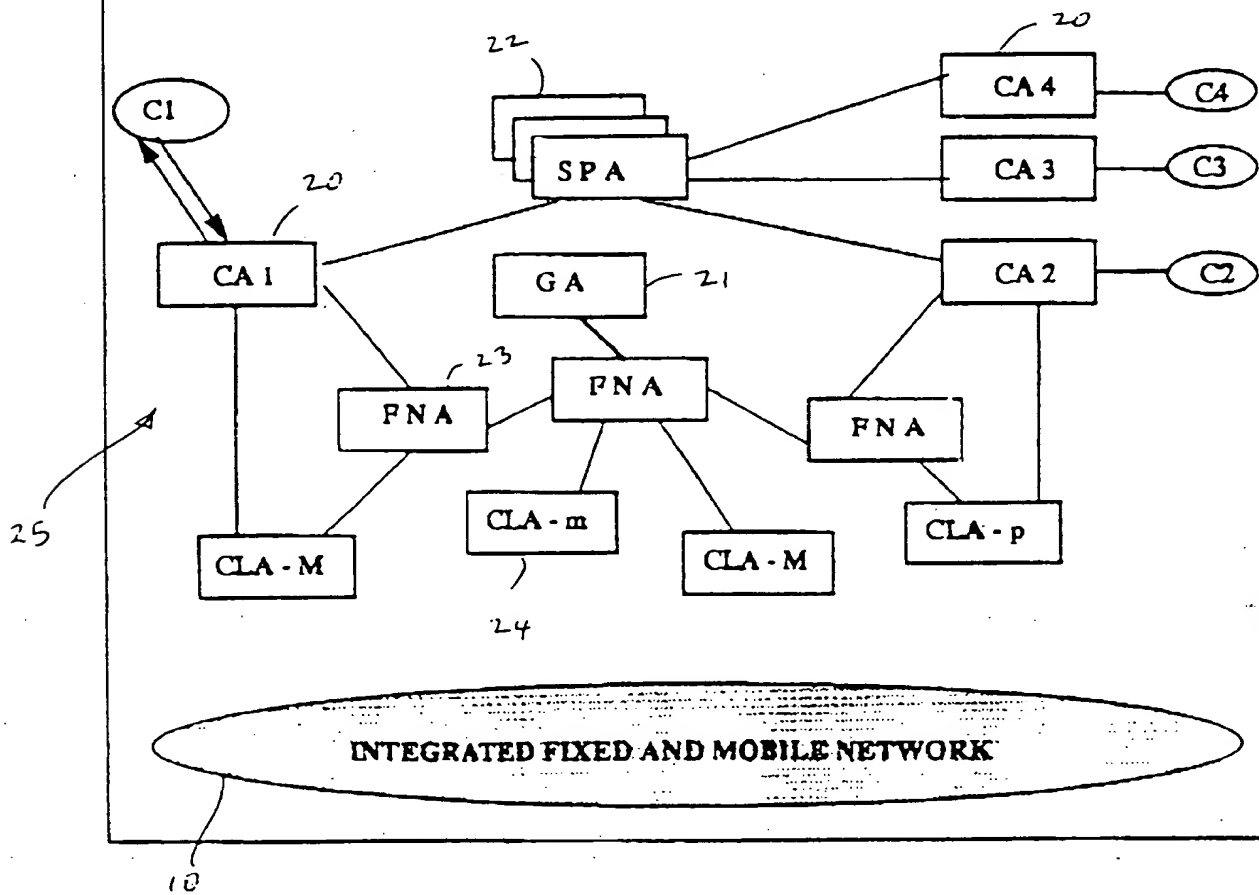
Micro - Cell

Road

Pico - Cell

Fig. 2 Heterogeneous Agent Architecture

Fig.3 Network Management Agents Control over the Network